Test reference year (TRY) in future climate for Croatia

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Introduction

- Test Reference Year (TRY) – artificially constructed year of hourly data which is representative for prevailing climate (multiyear period), selection of the most appropriate months from a number of different years
- Meteorological background for dynamic building energy simulations derived according to procedure from normative document HRN EN ISO 15927-4
- Meteorological conditions have major impact on heating and cooling energy demand
- Energy demand and consumption in future climate conditions considering climate change
- Q: Can our current homes endure these new conditions?

http://greenbuildingalliance.blogspot.hr

Data and Methods

Present TRY0 P0 1983-2005

- Zagreb-Maksimir meteorological station
- SIS solar radiation 1983-2005 CM-CAF, EUMETSAT
- Hourly data
  - Air temperature (T)
  - Relative humidity (RH)
  - Wind speed (WS)
  - Global solar radiation (GR)
- 8760 hourly values smoothed at month-to-month joints - possibility of using in the loop

Future TRY1 P1 2011-2040
TRY2 P2 2041-2070

- Climate model CNRM-CM5 (Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique CNRM/CERFACS)
- RCP4.5 scenario
- Delta change between P0 model data and P1 or P2 model data
- Adding absolute values (T) and relative values (RH, WS, GR) to TRY0

Results

Temperature

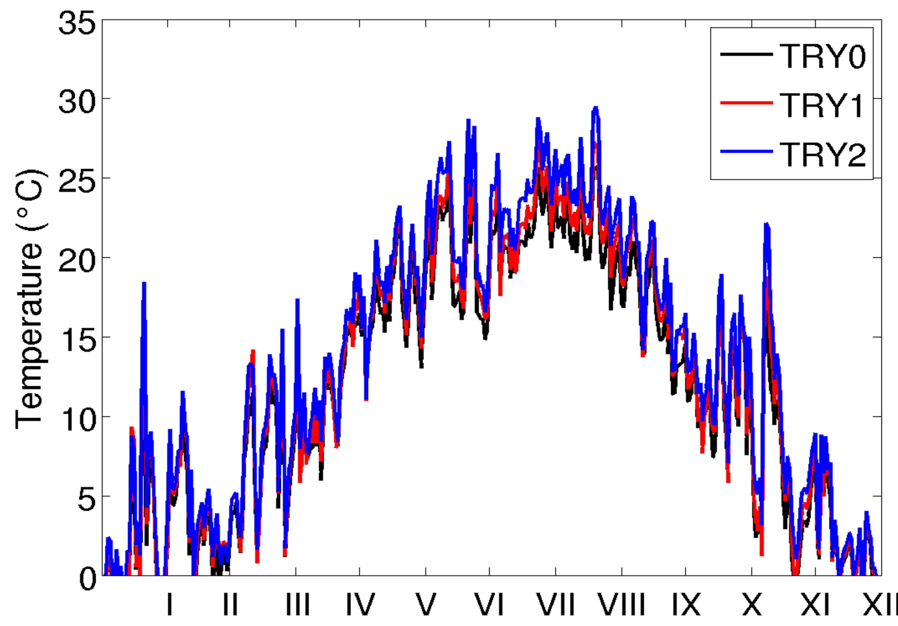

Figure 1. Daily mean temperature at Zagreb-Maksimir meteorological station derived from TRY hourly data.

Table 1. Mean temperature at Zagreb-Maksimir meteorological station for period 1983-2005 and corresponding standard deviation. Mean annual and seasonal temperature in TRY0, TRY1 and TRY2. The highest changes are bold. Absolute frequency of T≥30°C T<0°C.

	Period	T_{ann} (°C)	T_{DJF} (°C)	T_{MAM} (°C)	T_{JJA} (°C)	T_{SON} (°C)	T≥30°C (number of events)	T<0°C (number of events)
T_{mean}	1983-2005	11.1	11.5	20.6	11.0	1.2	-	-
T_{stdev}	1983-2005	0.8	1.3	1.1	1.2	0.9	-	-
T_{mean}	TRY0	11.4	1.8	11.7	20.8	11.2	48	883
T_{mean}	TRY1	12.3	2.4	12.4	**22.0**	12.1	165	748
T_{mean}	TRY2	13.3	3.1	13.0	**23.6**	13.2	296	566

- According to mean annual temperature, TRY0 is representative for multiyear period
- By the 2070s mean annual temperature of TRY is expected to be almost 2°C higher than in TRY0
- Highest absolute change is in summer and lowest in winter and spring
- Absolute frequency of T≥30°C in hourly data is increasing in TRY1 and TRY2 (3.4 times, i.e. 6.1 times higher than in TRY0)
- Absolute frequency of T<0°C is decreasing and in TRY2 it is at 64% of the value in TRY0

Relative humidity

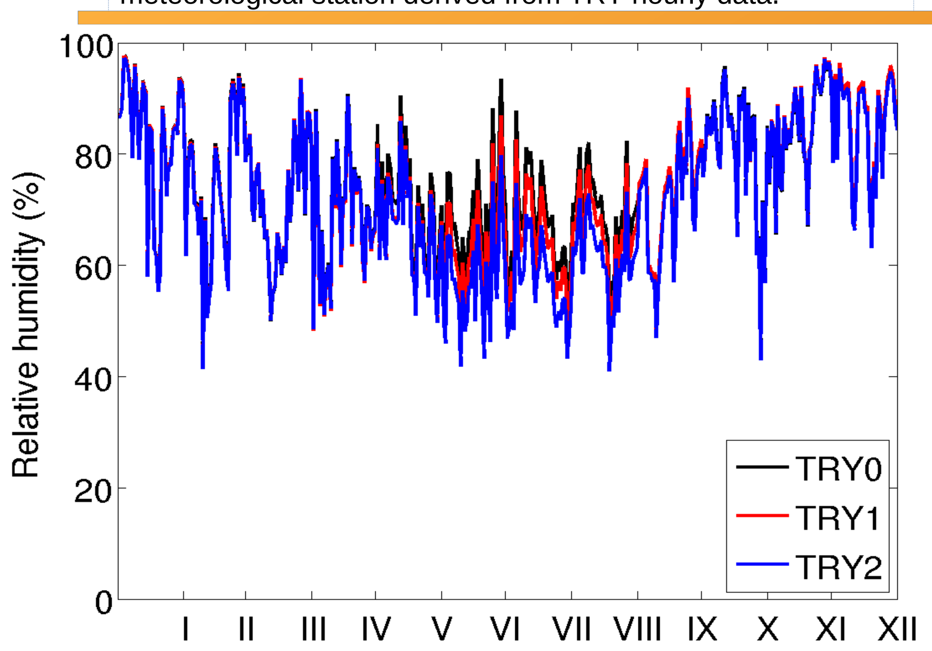

Figure 2. Daily mean relative humidity at Zagreb-Maksimir meteorological station derived from TRY hourly data.

Table 2. Mean relative humidity at Zagreb-Maksimir meteorological station for period 1983-2005 and corresponding standard deviation. Mean annual and seasonal relative humidity in TRY0, TRY1 and TRY2. The highest changes are bold.

	Period	RH_{ann} (%)	RH_{DJF} (%)	RH_{MAM} (%)	RH_{JJA} (%)	RH_{SON} (%)
RH_{mean}	1983-2005	74.6	81.4	67.6	68.9	80.8
RH_{stdev}	1983-2005	1.9	2.0	3.1	4.0	1.9
RH_{mean}	TRY0	74.1	80.4	69.9	67.5	78.8
RH_{mean}	TRY1	73.0	80.5	68.8	**63.6**	79.1
RH_{mean}	TRY2	71.4	80.0	68.7	**58.4**	78.6

- Mean annual RH decreases by only 2.7% in TRY2 but more emphasized are seasonal changes
- Easily noticeable are lower values in TRY1 and TRY2 during summer and partly during spring and autumn – cooling season
- Summer values are by 3.9%, i.e. 9.1% lower than in TRY0
- In TRY1 winter and autumn relative humidity is slightly higher than in TRY0

Wind speed

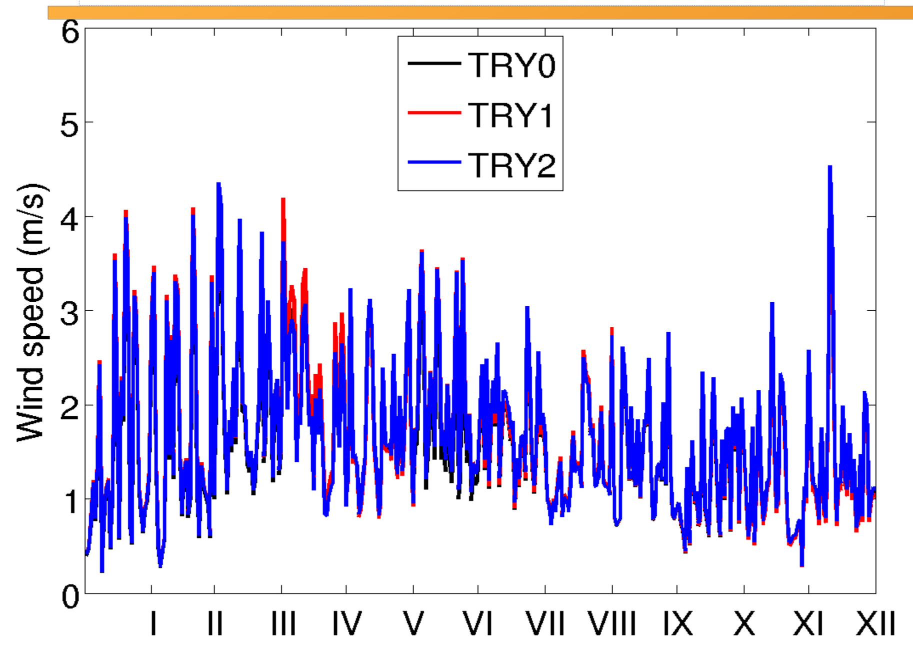

Figure 3. Daily mean wind speed at Zagreb-Maksimir meteorological station derived from TRY hourly data.

Table 3. Mean wind speed at Zagreb-Maksimir meteorological station for period 1983-2005 and corresponding standard deviation. Mean annual and seasonal wind speed in TRY0, TRY1 and TRY2. The highest changes are bold. Absolute frequency of WS≥8 m/s.

	Period	WS_{ann}(m/s)	WS_{DJF}(m/s)	WS_{MAM}(m/s)	WS_{JJA}(m/s)	WS_{SON}(m/s)	WS≥8 m/s (number of events)
WS_{mean}	**1983-2005**	1.5	1.5	1.9	1.5	1.3	-
WS_{stdev}	**1983-2005**	0.1	0.2	0.3	0.2	0.1	-
WS_{mean}	**TRY0**	1.6	1.5	1.9	1.6	1.2	2
WS_{mean}	**TRY1**	1.6	1.5	**2.0**	1.7	1.2	5
WS_{mean}	**TRY2**	1.6	1.5	1.9	1.7	**1.3**	4

- Mean annual wind speed in all TRYs is the same
- Mean wind speed during winter shows also stability but there are differences during spring in TRY1 and especially during summer in both future TRYs
- The highest relative increase of 8.3% is in autumn in TRY2 but the highest mean WS is 2 m/s in spring in TRY1
- Fresh breeze (WS≥8 m/s) events are rare in TRY but increase in TRY1 and TRY2 is noticeable which indicates increase of number of extreme events

Global radiation

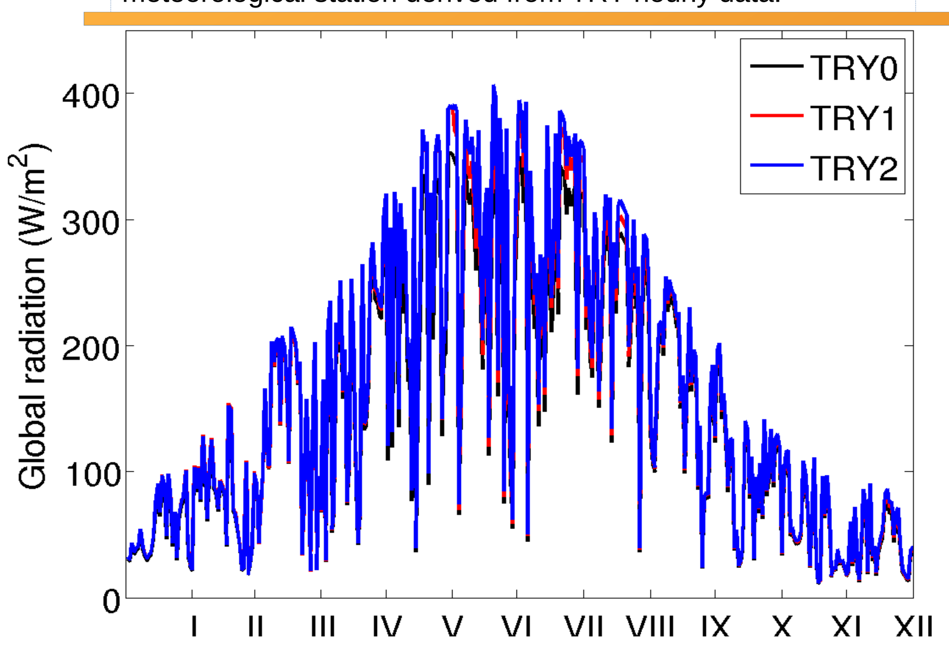

Figure 4. Daily mean global radiation at Zagreb-Maksimir meteorological station derived from TRY hourly data.

Table 4. Mean global radiation at Zagreb-Maksimir meteorological station for period 1983-2005 and corresponding standard deviation. Mean global radiation in TRY0, TRY1 and TRY2. The highest changes are bold. Absolute frequency of GR≥1000 W/m².

	Period	GR_{ann}(W/m²)	GR_{DJF}(W/m²)	GR_{MAM}(W/m²)	GR_{JJA}(W/m²)	GR_{SON}(W/m²)	GR≥1000 W/m² (number of events)
GR_{mean}	**1983-2005**	151.2	61.4	186.4	246.9	108.1	-
GR_{stdev}	**1983-2005**	6.1	6.8	10.3	12.0	7.8	-
GR_{mean}	**TRY0**	148.0	56.5	180.0	250.4	103.7	2
GR_{mean}	**TRY1**	156.6	59.6	190.2	**267.7**	107.3	39
GR_{mean}	**TRY2**	160.2	59.9	191.6	**279.3**	108.5	78

- Mean annual value in TRY1 is 3.6%, i.e. 6% in TRY2 higher than in TRY0 (Tab 4)
- Although low, changes are not equally distributed throughout the year
- Highest increase is evident during summer (11.5% in TRY2) and lowest during autumn (around 4% in future TRYs) (Fig 4)
- Although small amounts, cooling season is receiving more solar radiation
- In TRY0 only 2 events with global radiation higher than 1000 W/m2 were determined but in future TRYs there are 39, i.e. 78 such events

Conclusion

- Changes are not equally distributed throughout the year
- Lower relative humidity combined with higher temperature and higher wind speed indicate dry and hot summers with larger number of extreme events
- Diffuse solar radiation is also part of TRY (not shown in poster) and show similar behavior for future TRYs as global solar radiation
- Considering only test reference year, heating demand in future will decrease and cooling demand will increase
- Cooling season changes of meteorological parameters are expected to have larger influence on increase of energy demand
- Test reference year for future periods should be included in adaptation to climate change studies
- Further research – run dynamic building energy simulations with TRY1 and TRY2 to estimate change in energy demand in future climate

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